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Shellfish Cultivation in Scotland

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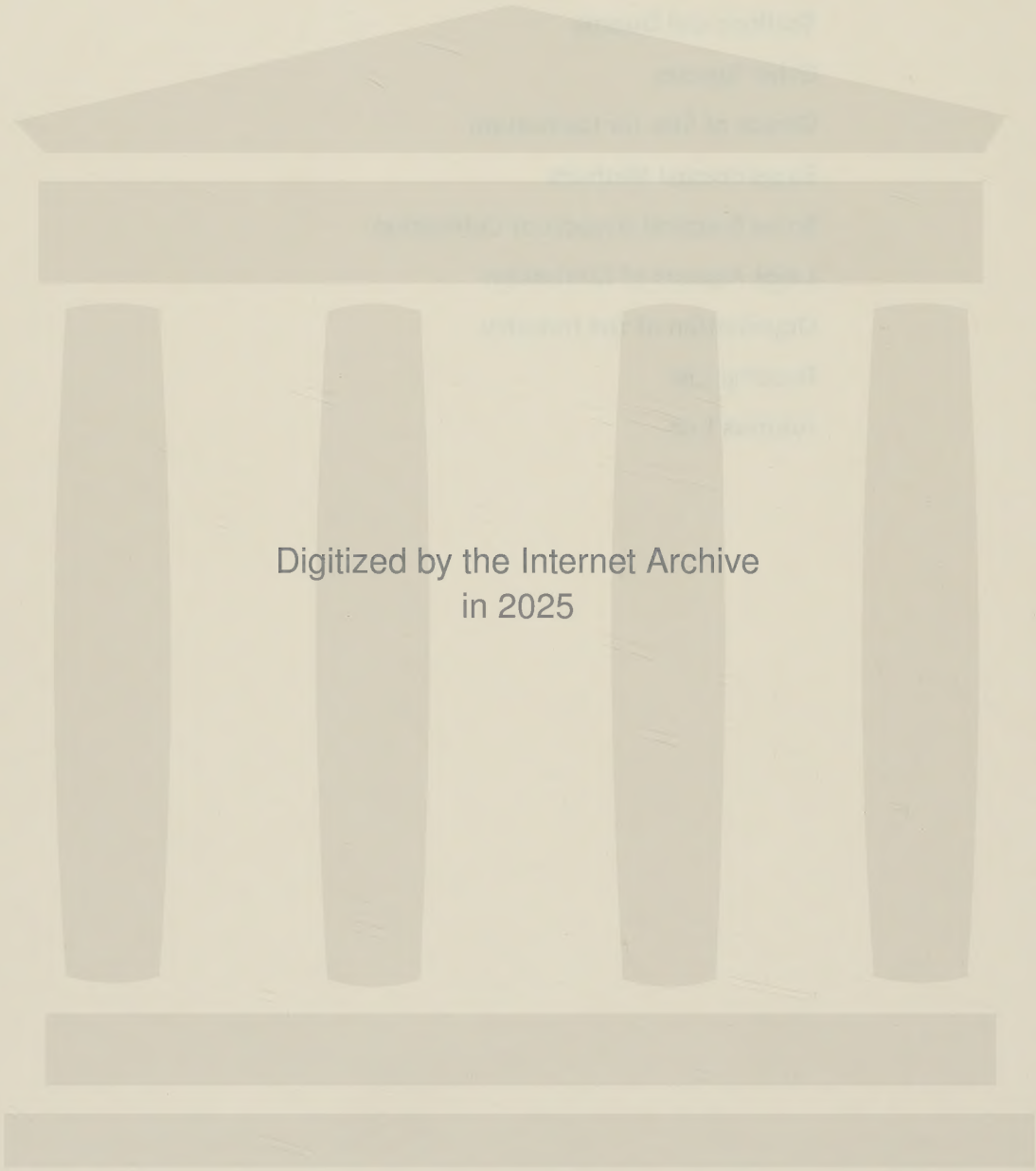

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Shellfish Cultivation in Scotland

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Introduction

There is a continuing and growing interest in shellfish cultivation in Scotland. This pamphlet sets out to describe the biology of the cultivated species, methods of cultivation and the various legal and other aspects. It is concerned almost entirely with bivalve molluscs such as mussels and oysters, as they have advantages for cultivation over other animals. They are non-motile or of limited motility and therefore easy to harvest, and can be kept in captivity without the need for constant attention and artifical feeding.

The various methods of shellfish cultivation lend themselves well to part-time activities and thus help considerably in places such as the Highlands and Islands where employment is scarce. They combine particularly well with the traditional activities of crofting and inshore fishing.

Scottish waters, particularly on the west coast, are well suited to bivalve cultivation for the following reasons:-

1. They receive the benefit of the North Atlantic Drift, with sea temperatures higher than in many other areas of similar latitude.
2. The geographical features include many inlets and islands which offer local shelter.
3. Many inlets are partly cut off from the open sea by narrow entrances with shallow sills, helping to produce relatively high summer temperatures.
4. They are almost entirely free from troublesome pests and diseases, and from bacterial and chemical pollution.

Biology

Almost all shellfish belong to two main groups of animals: the Crustacea, including lobsters and crabs, and the Mollusca, animals such as periwinkles, mussels, oysters and scallops. When dealing with shellfish it is often necessary to use their scientific names, as some of the common names such as "clam" or "shrimp" mean different things in different places.

There is now some interest in the artificial cultivation of the lobster *Homarus gammarus* but this carnivorous species is not considered further here, as artificial feeding is necessary and it is likely to be some time before artificial production could be done on an economic scale. There is, however, considerable interest in the re-stocking of natural fishing grounds with young animals reared to a size at which they are able to fend for themselves in nature. This is still at an experimental stage.

Bivalve molluscs, however, feed mainly on phytoplankton, the minute plants which grow in the surface layers of the sea. Sea water is drawn into the shell, passed through the gills and out again (see Fig. 1). Food particles become attached to the layer of mucus on the gills and are transported by the movement of tiny hair-like projections or cilia. Suitable food passes into the mouth, while the rest is discarded and ejected from the shell in the out-going current. The rate of growth of a bivalve depends not only on the richness of the food supply but also on temperature. At low temperatures, feeding activity is slow and food intake is low. The rate at which shell material is manufactured by the mantle is less affected by temperature, so that fast growing individuals have thin shells, while animals which are growing more slowly have relatively thick shells.

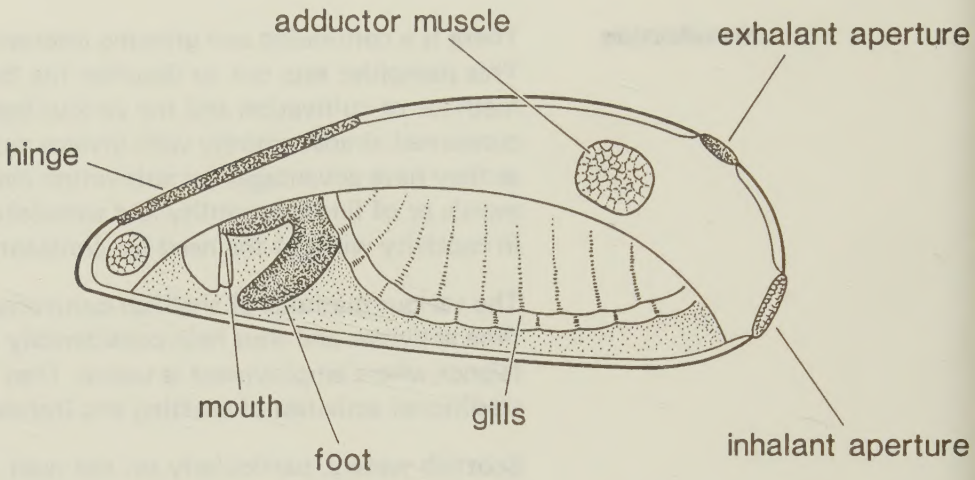

Figure 1. Mussel with left valve of shell and part of mantle removed.

Most bivalves reproduce by passing eggs and sperm into the out-going current from the shell cavity. (In the oyster *Ostrea edulis* fertilisation takes place in the mantle cavity.) The fertilised eggs develop into planktonic larvae which may drift for a considerable time (from a few days to several weeks) before reaching a surface suitable for settlement. The newly settled animals are known as spat. The conditions necessary are not fully understood but it is known that settlement varies greatly from place to place and from year to year.

In some species the adult animals may remain attached by cement (oysters) or byssus threads (mussels). In others the adults burough (cockles) or are capable of swimming (scallops and queens).

The Common Mussel
(Mytilus edulis)

The mussel is one of the commonest of all marine animals in Scottish waters. It occurs in dense beds, particularly in estuaries, but these animals are usually of poor quality because of overcrowding. Dense patches of small mussels are often found quite high on rocky shores. These grow very slowly, but if they are removed and transplanted to better growing areas they grow well. Natural beds of mussels may be fished by dredging; the smaller mussels in the catch can then be relaid in other areas and dredged up later when they have grown sufficiently. Other methods of cultivation depend on the provision of suitable settlement surfaces by artificial means. These are usually in the form of ropes which may be wound round poles on the fore-shore (the poles are known in France as *bouchots*) or may instead be sus-pended from rafts or buoys (Fig. 2). In the best areas ropes suspended in the

spring will become covered with a dense settlement of spat which will grow rapidly and reach marketable size within two years. They will be of good quality and free from the grit and pearls often found in mussels grown on the sea bed.

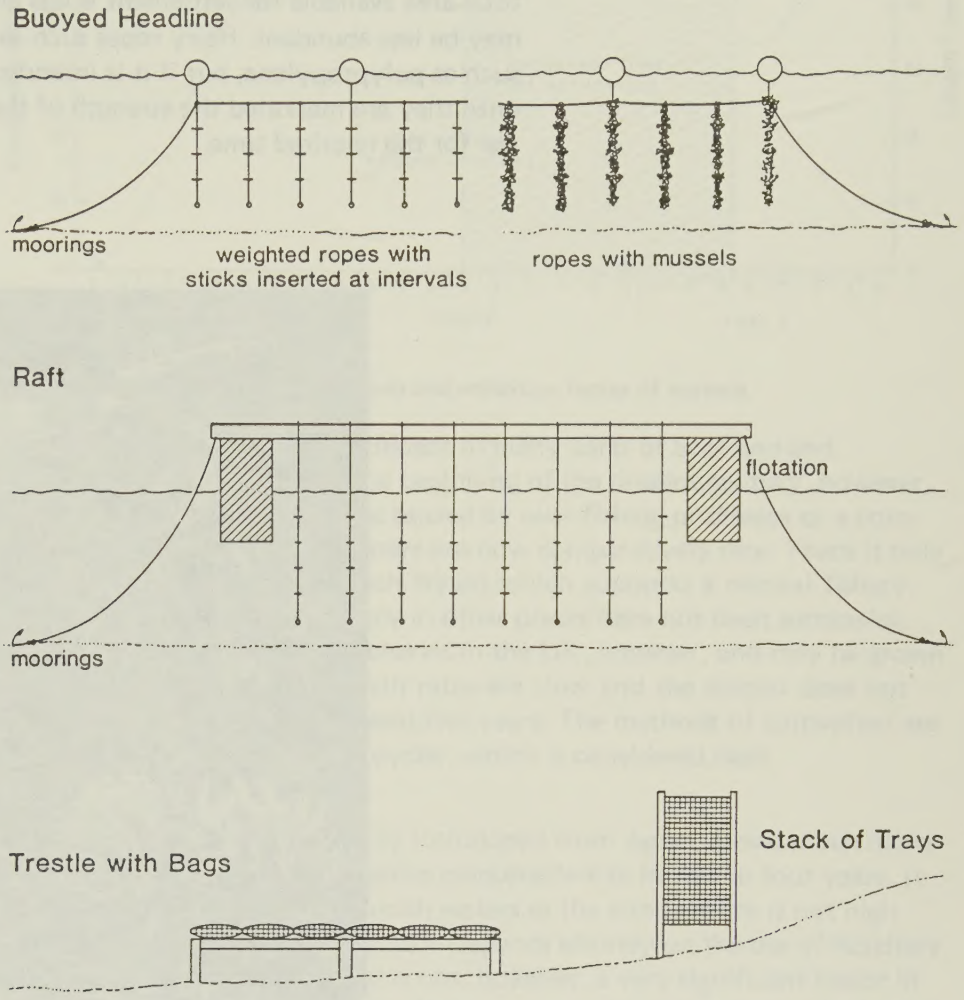

Figure 2. Typical systems for mussel ropes and oyster trays.

The fact that mussel cultivation is in principle so simple has given rise to the idea that it is also easy, but this is not necessarily so. There are many difficulties to be faced. Firstly, spatfall is very variable from place to place and from year to year. Secondly, good growing areas are also areas where growth of other organisms is good, and so the ropes become fouled with other species such as tube worms and sea squirts (see Plate I). Thirdly, in many areas predators such as the eider duck will play havoc with ropes which are not protected. Because of the uncertainties of spatfall it is advisable for operators to have several different sites or to co-operate with other farmers in the provision of spat. Assuming that a good spatfall has been obtained the ropes may be left as they are, in which case the mussels may be overcrowded and many will fall off. This may seem to be a waste, but any method of avoiding this depends on the thinning out of the mussels by hand and the use of the thinnings for cultivation by other methods. The best method of using these thinnings is to put them into netting tubes nowadays sometimes wrongly called *pergolare*. This is in fact the Italian word for frame structures or trellises from which the finished tubes are hung, and the tube itself is a *resta*. If the tube is of the correct material the mussels will push their way to the outside and grow as well as they do on a rope. If

the mussels remain within the tube their growth is likely to be restricted. Settlement ropes are best put out about a month before spatfall is expected. This enables them to receive a coating of small algae and hydroids on which the mussels can settle more easily. If the ropes are put out too early the settlement of other organisms may be too dense. If a clean rope is used the total area available for settlement is less and so the settlement of mussels may be less abundant. Hairy ropes such as coir are better than smooth ones such as polypropylene, but if it is intended to leave the mussels on the rope until they are marketed the strength of the material must be such that it will last for the required time.

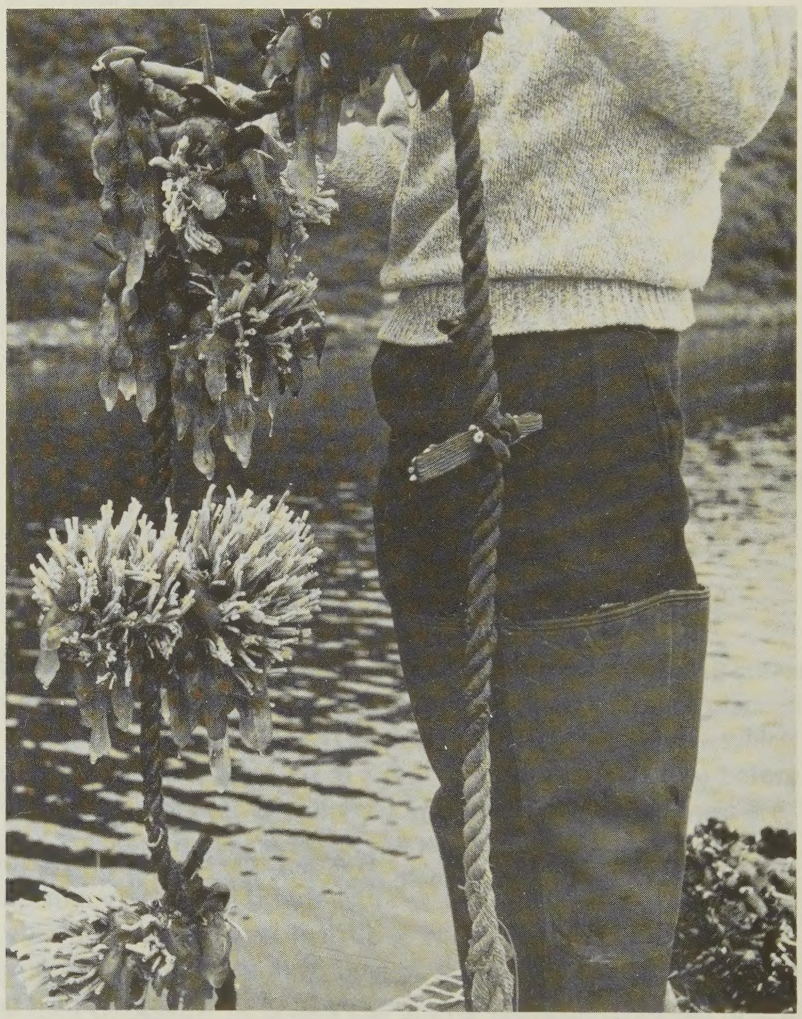

Plate I. Tube worms and sea squirts on mussel rope.

The time of settlement varies from place to place. In Loch Sween the best settlement is obtained in early summer. Further north in Sutherland, too, settlement occurs in the summer, but may also occur in the autumn.

Growth takes place during the summer and early autumn, but slows down or stops during the winter (Fig. 3).

The meat yield of mussels increases during the summer when feeding is good but declines over the winter when food is short. The worst condition is found just after spawning and mussels should not be sold at this time. Some experience is necessary to judge the time to stop selling, as mussels which appear to be in excellent condition may spawn in transit. The best time for harvesting is shown in the diagram (Fig. 3).

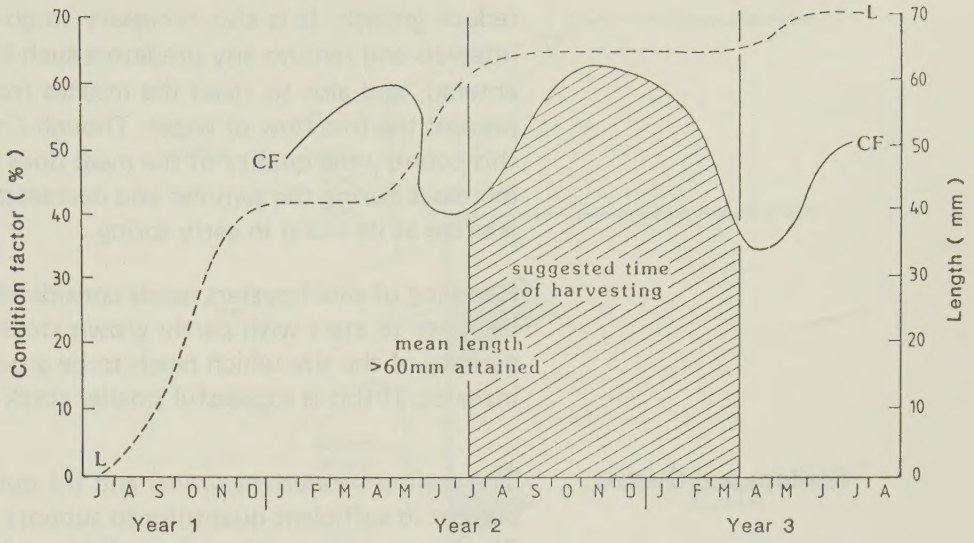

Figure 3. Growth and condition factor of mussels.

Oysters

Native Oyster *(Ostrea edulis)*

The native oyster was once abundant in many parts of Scotland and supported a large fishery. At the beginning of the present century, however, there was a big decline, perhaps caused by over-fishing or disease or a combination of the two. Native oysters are now comparatively rare. There is only one place left in Scotland (Loch Ryan) which supports a natural fishery. Experiments to revive the fishery in other places have not been successful. Seed is now available from hatcheries in the UK, however, and may be grown on in suitable places, but growth rates are slow and the animal does not reach a marketable size for at least five years. The methods of cultivation are similar to those for the Pacific oyster, which is considered next.

Pacific Oyster *(Crassostrea gigas)*

This species, which was originally introduced from Japan, grows much more quickly than the native and reaches marketable size in two to four years. It does not breed in nature in Scottish waters as the temperature is not high enough and the cultivation therefore depends entirely on the use of hatchery produced seed. The cost of seed is not, however, a very significant factor in the establishment of an economic farming operation and oyster cultivation is now successfully operated in a number of places. In fact, because there is no possibility of obtaining natural settlement, one of the big variables is cut out. The Pacific oyster may well be the most suitable species for a beginner to try to cultivate. The general principles involved are similar to those for mussels, and the more effort and expense is put into improving the conditions surrounding the individual animals the better the growth will be. The simplest method of cultivation is to place the seed directly on the shore and to leave them to fend for themselves. Losses due to crabs (*Carcinus* and *Cancer* spp) and starfish (*Asterias* and *Masthasterias*) are likely to be very high, however, and it is better to keep them in some form of tray or other container to prevent predation. The trays may be placed in stacks on the shore, in which case a large number of animals may be kept in a small space, or they may be spread on trestles – thus increasing the supply of food by having them surrounded with water (Fig. 2). A further development of this principle is to hang them from rafts. This may produce the best conditions but is also more expensive.

Growth rates vary enormously and it is important to avoid overcrowding. As the animals grow they need to be put into a larger number of trays. The aim should be to provide sufficient space for the animals to be spread in a tray without touching each other. Densities greater than this will considerably

reduce growth. It is also necessary to go through the trays at frequent intervals and remove any predators such as starfish or crabs which may have entered, and also to clean the meshes from encrusting organisms which prevent the free flow of water. Though *Crassostrea gigas* does not breed in this country the quality of the meat does vary seasonally. Meat yield increases during the summer and decreases during the winter, and condition is often at its worst in early spring.

Handling of small oysters needs considerable experience and it is best for the beginner to start with partly grown stock from an established nursery, perhaps of the size which needs to be grown for only one year in the first instance. If this is successful smaller stock could then be tried.

Scallops and Queens

The scallop (*Pecten maximus*) and the queen (*Chlamys opercularis*) are both present in sufficient quantities to support fisheries in a number of places. There is not yet any sign of overfishing of Scottish stocks, but as pressure increases the stocks may decline at some time in the future. This has happened in Japan where a related species was considerably overfished but methods of cultivation were developed which have been very successful.

Spat of the two species may be obtained by putting out artificial collectors. The young animals become attached by byssal threads like those of the mussel, but they soon become detached and swim away. In nature spat attaches to weeds and hydroids on the sea bed. The best kind of collector, based on methods used in Japan, consists of an outer mesh bag with other fine mesh netting pushed inside. The larvae enter through the outer covering and settle on the inner material, where they remain attached for a time. By the time they are ready to release themselves from the attachment they have grown too large to escape through the outer meshes. These collectors may be made into strings (see Fig. 4) and placed in areas where it is thought the currents are likely to bring in supplies of larvae. Cultivation in Scotland is still at an experimental stage but it has been shown that many places in the west of Scotland are suitable for the collection of spat of both species. They may be grown on in suspended cages but suffer the usual difficulties with predators and competing organisms. They are unable to seal their shells completely, and must be kept under water. They may be transported alive, however, packed in damp seaweed or other material. This is better than transporting them in small amounts of water. Recent experiments have been aimed at releasing partly grown animals on the bottom to augment natural stocks. Only the adductor muscle and gonad are normally eaten in these species, but recent attempts have been made by the Sea Fish Industry Authority to market small queens under the name of "princess scallops" and it is intended that the whole of the contents of the shell should be eaten as in mussels and oysters.

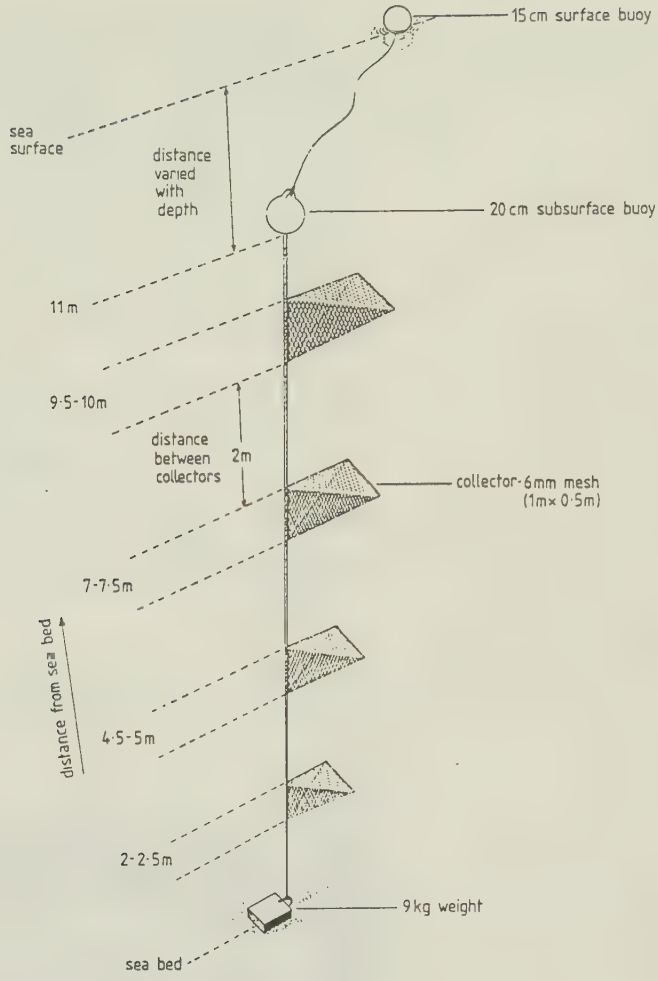

Figure 4. A string of scallop spat collectors.

Other Species

A variety of other bivalves are edible and some may well be suitable for cultivation but at the moment the only one under serious consideration is the Manila clam, *Tapes semi-decussata,* which is available from hatcheries. Much work remains to be done before other species such as the native *Tapes decussata* or perhaps such animals as razor shells (species of *Solen* and *Ensis*) may be considered in the future. The cockle *Cerastoderma edule* has already been considered, and though growth rates may be improved by transplanting the animals to a position lower on the shore, the species is not of very great value and this operation is not likely to be a commercial success.

The periwinkle, *Littorina littorea,* forms an important fishery in Scotland but is not really suitable for cultivation, as it feeds, not by filtering plankton, but by rasping small seaweeds from the rocks. If placed in oyster trays, periwinkles help to keep the meshes clean.

Choice of Site for Cultivation

The first essential is shelter. It is best to see a site under a variety of weather conditions, as what may look very sheltered may be just the opposite with the wind in another direction. The severity of the effect of wind depends on the amount of open water across which the wind has blown before it reaches the shore, so one should look for the direction which would have the longest fetch and imagine a very strong wind in that direction. On the other hand in areas almost completely surrounded by land the winds may sometimes funnel in gaps between the hills and cause intense local disturbances under some conditions. The advice of local inhabitants should be sought.

It is also necessary to know the range of tidal heights. This is of great importance if it is contemplated that work will take place on the shore, but is also needed for such things as determining the correct length of anchor ropes for rafts and other structures. A full tidal cycle lasts just over 12 hours and the height of the high and low waters varies from day to day depending on the positions of the sun and the moon. The highest and lowest tides (spring tides) occur just after full moon and new moon. The tides with the lowest variation, that is the lowest high tides and the highest low tides (neap tides) occur at the intervals between the springs. The most extreme springs of all occur in spring and autumn.

Details of the tidal conditions at different locations may be found in the Admiralty Tide Tables and North and West Coast of Scotland Pilots, but it must be realised that weather conditions can have quite a considerable effect on the height of the tide. In many places the line of orange lichens on the rocks at the top of the shore may be taken as an approximate level for high water spring tides. Low water springs on the other hand are the tides where the sublittoral weeds such as *Laminaria* (Plate II) are just beginning to be exposed.

Plate II. ***Laminaria*** **exposed at low water.**

In some areas the actual tidal streams are of importance. If they are very strong they may interfere with apparatus used in cultivation. The strongest tidal streams are in the narrows between islands or between islands and the mainland. The nature of the bottom is of obvious importance. In the most sheltered areas the bottom is likely to be very muddy. For suspended cultivation this does not matter, but if it is required to put things onto the bottom or onto the shore a firmer substratum mixed with sand or stones is necessary. Temperature is another factor of obvious importance and again it will vary with the state of the tide, the time of day and the time of year. Some examples of sites investigated by the Marine Laboratory are shown in Figure 5. In general, areas which are cut off from the open sea will have warmer water in the summer but colder water in the winter as compared with the temperature of the open sea. The high summer temperatures will

enhance growth of cultivated species but the low winter temperatures will not have much effect since growth is normally slow and food scarce at that time. Mortalities may occur in exceptionally cold conditions if animals are exposed on the shore or affected by surface ice.

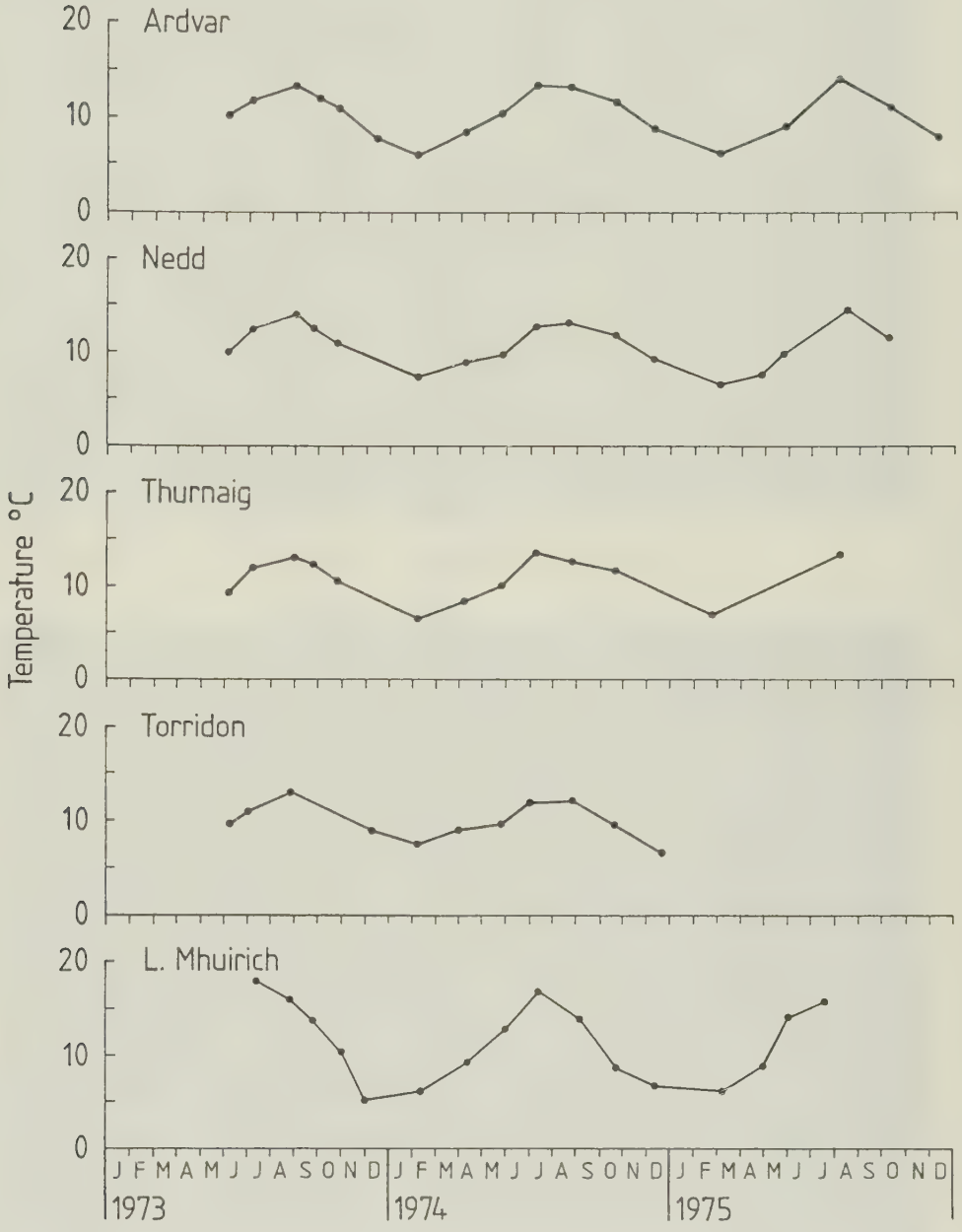

Figure 5. Temperature at 2 m at sites investigated by Marine Laboratory.

The salinity must not vary greatly (Fig. 6). The amount of variation permissible depends on the species. Mussels and oysters, which can close their shells completely, can withstand considerable variations in salinity, even to the extent of being immersed in completely fresh water for a time. On the other hand scallops and queens, which cannot completely close themselves, are vulnerable to lower salinities. Under calm weather conditions fresh water tends to accumulate near the surface so that it is necessary to take water samples from several depths to determine the salinities to which the cultivated animals will be exposed.

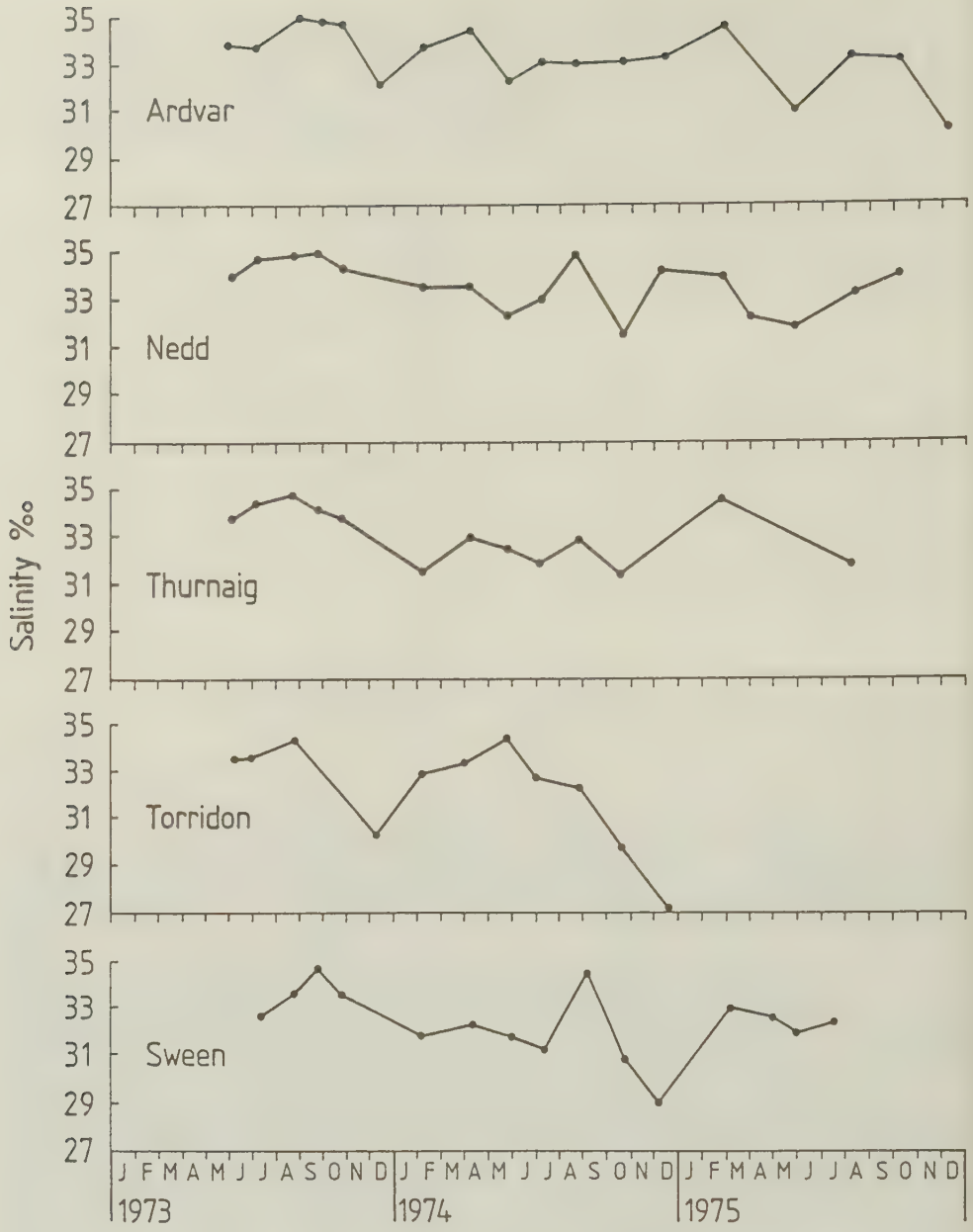

Figure 6. Salinity at 2 m at sites investigated by Marine Laboratory.

A number of other factors may be mentioned in connection with site selection. The ideal site is probably fairly small, with a narrow entrance to the sea, and if this entrance is also shallow, forming a sill, the exchange of water with the sea outside will be restricted, and this will allow the build up of higher temperatures in the summer.

Other species form a useful clue to the desirability of a particular site. The seaweed *Ascophyllum nodosum* (Plate III) occurs only in fairly sheltered waters, so its presence is a good sign. In very sheltered places, an unattached form of this species is present and is not dislodged by the water movements (Plate IV). At a glance this form looks rather more like the weed *Pelvetia* (Plate V), which occurs around high water neaps. The presence of shells of the native oyster is an encouraging sign; the presence of mussels may not be of much significance as they occur in some very exposed situations. In the richest areas, the rocks just below low water will be covered with a mass of sponges and other organisms.

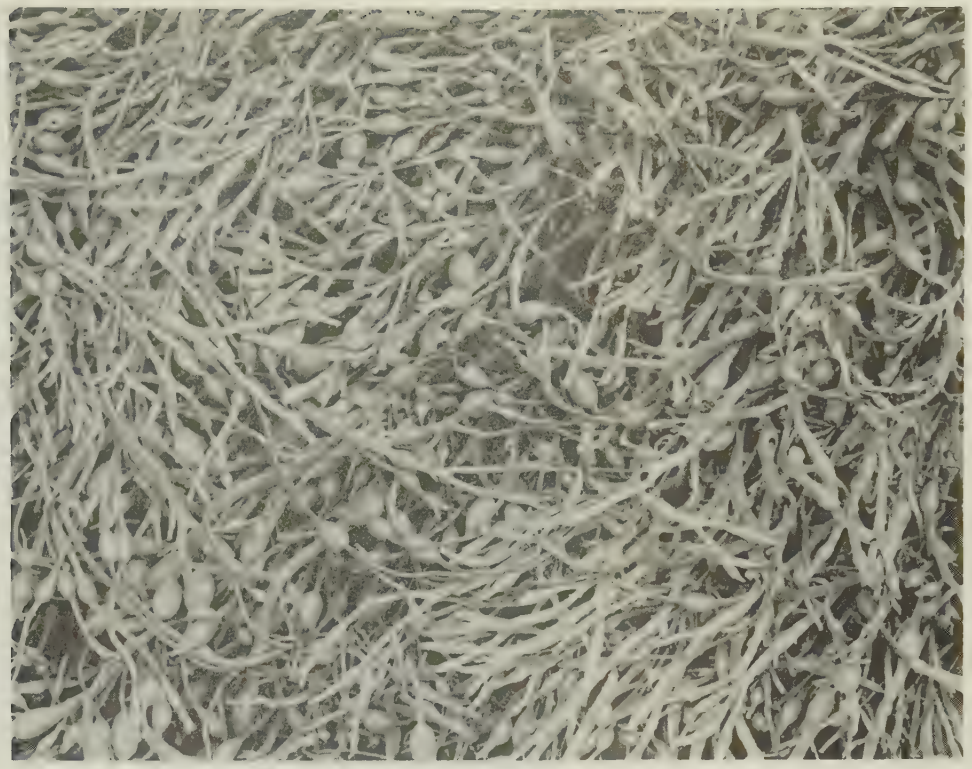

Plate III. *Ascophyllum nodosum.*

Plate IV. **Unattached form of** *Ascophyllum.*

Plate V. *Pelvetia canaliculata* **at high water neap tide level.**

Experimental Methods

While it is not suggested that all workers will wish to carry out detailed scientific experiments, it is essential to keep careful notes of all activities. It may be useful if small scale experiments are run alongside the main methods of cultivation, as they will enable improvements to be worked out for the future. In this connection there are several measurements which can be made and the details of some of these are included in the following notes.

Tidal heights may be determined by noting the position of the tide on temporary poles erected for this purpose. The height of various points on the shore may then be calculated and by using the tide tables the degree of exposure may be worked out. A small amount of exposure cuts down fouling of trays but too much exposure reduces growth rates.

Temperature can be easily measured with an ordinary thermometer.

Salinity is most easily determined from density. Density can be measured using a hydrometer and the readings transformed into salinities by the use of Figure 7. Temperature has some effect on the density but it is not really important over the range we are concerned with.

Samples of water may be taken from below the surface by the use of a weighted bottle with a string attached to the cork. The bottle is then lowered to a known depth and the cork pulled out.

Survival of animals is just as important as growth rate so whenever a tray is filled the number of animals should be counted carefully. When it is examined later, the number of live animals should again be counted. There may be signs of shells from dead animals or their shells may be missing completely. Only by making careful notes of numbers can the real degree of survival be established.

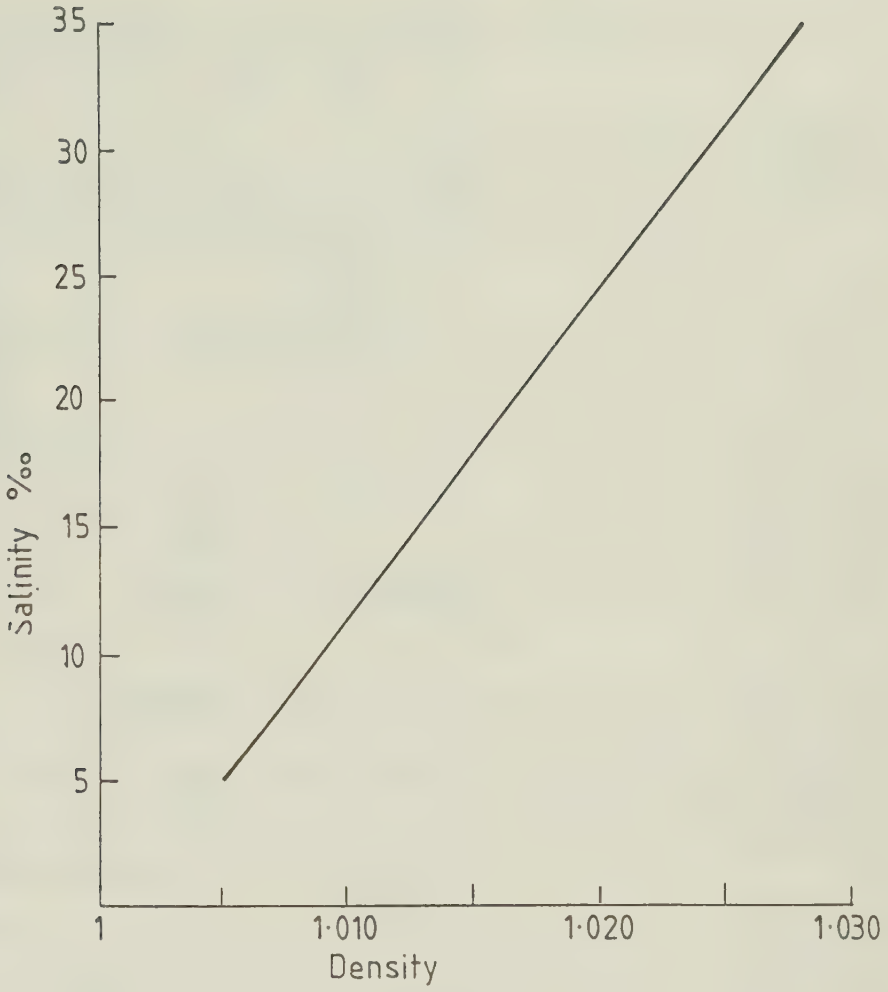

Figure 7. Relation between density and salinity at 10°C.

Growth can be measured in two ways, either by length or by weight. In scallops, queens and mussels the length is quite easy to determine, but because of the irregular shape of oysters weight is perhaps a better measurement.

Because of the variation in growth rate between different animals, a large random sample should always be used when trying to determine the mean length or mean weight.

A note should be made of the other animals present in the cages. Those which are competitors should be noted, and if they are removed from the cage this should also be recorded. Predators such as crabs and starfish should also be removed and a note made of their presence and size.

Meat yields can be determined in a variety of ways using either weight or volume. For animals which can close the shell completely, eg oysters and mussels, volume is best measured by lowering the animal or part of the animal into a measuring cylinder containing water, when the increase in volume can be read off the scale. The important measurements are the total weight or volume, the shell weight or volume and the meat weight or volume and also the total internal volume of the shell which can be derived by subtraction. The meat weight can then be expressed in a variety of ways, either as a percentage of the total weight of the animal or related to the shell or to the total internal space. Some examples are given in Table I. Whatever method is adopted the exact details should be the same every time the measurement is taken, as variations in technique may cause differences in

readings, particularly in meats, where evaporation may take place thus reducing the weight. In oysters a leakage of fluid from the tissues takes place fairly quickly after the meat is removed from the shell.

Table I

Meat content of a sample of oysters expressed in various ways

Percentage composition by weight:

Dry meat	4.5
Water in meat	9.5
Water in body cavity	18.0
Water in shell	14.0
Dry shell	54.0
	100.0

Wet meat yield	$\frac{\text{Wet meat}}{\text{Total}} \times 100$		14.0
Dry meat yield	$\frac{\text{Wet meat}}{\text{Total}} \times 1000$		45.0
Wet condition factor	$\frac{\text{Wet meat}}{*\text{Internal volume}} \times 100$		30.0
Dry condition factor	$\frac{\text{Dry meat}}{*\text{Internal volume}} \times 1000$		97.8

* Internal volume is approximately total weight–shell weight, as specific gravity of meat is close to 1.

Shell condition index	$\frac{\text{Dry meat}}{\text{Dry shell}} \times 1000$		83.3

Another factor which is of importance in connection with the meat is the actual quality, but it is difficult to give precise rules about this. A little experience will show the difference between a recently spent animal, which may be grey and watery looking, and one which is full of gonad products (for example see Plate VI), and although quantitative methods are difficult to work out some form of notes should be kept of this also.

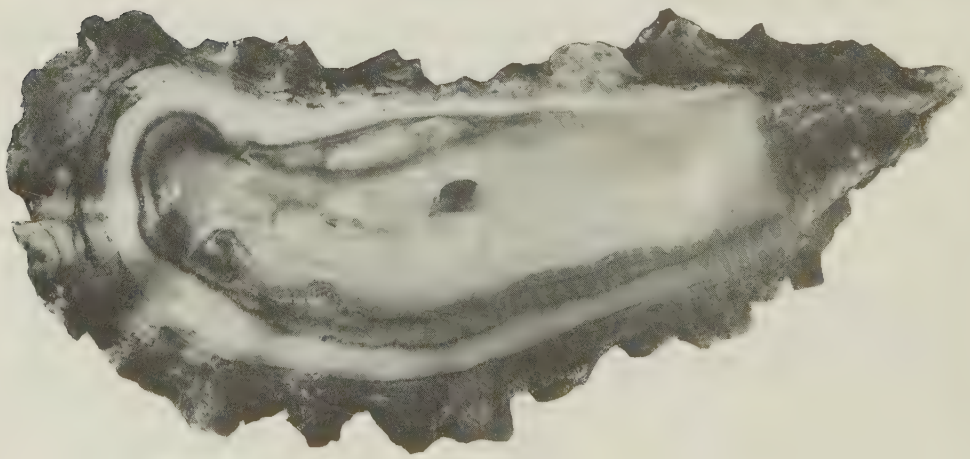

Plate VI. *Crassostrea gigas* **showing full gonad.**

In scallops and queens the various parts of the body (the muscle, the gonad and the rest of the tissues) may be measured separately.

Some Practical Aspects of Cultivation

In the actual details of methods of cultivation there is scope for considerable initiative, but some general points will be made here. The whole aim of cultivation is to provide the animals with the right conditions so that a plentiful supply of food is brought to them by water currents.

The cages used to contain the animals may be specially designed for the purpose or adapted from other apparatus such as the trays used by bakers. Special trays are usually designed to stack so that a number may be placed together and the uppermost forms the lid of the series. Another important kind of cage is the oyster bag which consists of a length of netting of stiff mesh which can be sealed at its ends to form a pillow shape in which the oysters are kept. Special designs of cage have been produced by the Japanese. The mesh size is very important. Too large a mesh may allow the animals to escape, but too small a mesh reduces growth rates by cutting down flow of water through the cage and also by the relative ease with which the meshes are blocked by the growth of fouling organisms.

Ropes for mussel cultivation are best obtained second hand, thus reducing the cost appreciably. Old netting may also be used for settlement and growth of mussels and a variety of materials have been used to make up collectors for scallop and queen spat. These include various kinds of bags normally used for containing vegetables, and by choosing the correct size and mesh size various combinations are possible.

Flotation of cages may be by the use of buoyed headlines or rafts. The headlines may be buoyed with specially purchased equipment or with old containers or blocks of polystyrene enclosed in suitable covers, which are considerably cheaper than buoys.

Rafts may also be constructed from a variety of materials, the simplest form being two tree trunks with cross members or other forms of wooden structure depending on the supplies of local timber. They are best, however, to include blocks of polystyrene, which is very buoyant and relatively easy to obtain. The framework may also be made of rigid plastic tubing or of metal. Rafts should be either small enough to be worked from a small boat or large enough to have a working platform on the raft itself. Headlines and rafts need to be anchored securely. It is almost impossible to over-emphasise the importance of this. Many first attempts at cultivation have ended in disaster with rafts blown ashore and other equipment disappearing completely. The anchor ropes should be three times the water depth and the anchors should be of sufficient weight. As a rough guide a small raft of 3 x 4 m needs four anchors of at least 15 kg each.

In this connection it should be noted that blocks of concrete, which are fairly easy to make, are not as effective under water as might be supposed. This is because the density of concrete is quite low.

The more attention the animals being cultivated receive the better the results are likely to be. They should be sorted and graded at intervals, the cages thoroughly cleaned and any predators removed. Faster growing individuals should be removed and placed in separate cages, so that they are not held back by want of space. The slower growing individuals are likely to remain slow growing and it may be necessary to keep them for a longer period before they reach commercial size.

There is a limit to the number of animals which can be grown in a given area. Overstocking may result in poor growth caused by shortage of food or the accumulation of waste.

The exact timing of the various operations can be determined only by experience. Animals for on-growing should be put out in the early spring so that they get the benefit of the spring plankton bloom, and by autumn they should have produced their best growth. Collection of spat is more complicated and really needs local knowledge. In general, the further north the later the settlement, but it is worth doing preliminary experiments on settlement to determine the best time in a particular area.

A few other matters deserve mentioning. It is essential that knots are made securely, and are self-tightening under load. Bags and cages may be closed in a variety of ways, which include sewing up with thin twine or wire and using clips, hooks or elastic bands. It should be remembered that conditions may be very uncomfortable in the field and a method should be chosen which can be managed when the hands are very cold.

Legal Aspects of Cultivation

In Scotland mussels and oysters belong to the Crown, and strictly speaking they may not be removed without permission. In many places the public have, however, by long usage, obtained the right to collect mussels. If either species is cultivated, a Crown lease must be obtained so that there is no doubt about the ownership of the farmed animals. The Crown owns the sea bed and the foreshore, though exclusive rights may be granted to individuals for particular purposes. Application should be made to the Crown Estate Commissioners in Edinburgh (for address see page 19).

A lease will not be granted until the Department of Transport have also given permission, as they will be concerned that freedom of navigation is not interfered with by your activities. They will require to know the details of rafts and other structures which it is proposed to use.

There are other controls under the Sea Fisheries (Shellfish) Act 1967 as amended by the Diseases of Fish Act 1983. These are designed to prevent the spread of pests and diseases. Any person wishing to carry on a shellfish farming business in Scotland, whether or not for profit, must register with the Department of Agriculture and Fisheries for Scotland in Edinburgh. A certain amount of basic information is required and the business must maintain records showing the movement of shellfish in and out of the farm. They must also supply once a year a summary of shellfish movements.

Most areas in Scotland are free from pests and diseases. A few areas in the Firth of Clyde, the Firth of Forth and a very small part of Loch Sween are regarded as "dirty" areas as they contain *Mytilicola intestinalis,* an elongated parasitic copepod, commonly known as "red worm", which occurs in the gut of the mussel and other bivalves. Regulations prohibit the deposit of mussels and other shellfish from these areas into the clean areas of Scotland. In addition shellfish from outside Scotland may only be brought in under certain conditions and a licence must be obtained from the Department of Agriculture and Fisheries for Scotland. These controls are necessary to maintain the position of Scotland in relation to shellfish diseases. Over the years a number of serious diseases of oysters have spread through other parts of Europe and recently into the south of England. It is essential that such diseases should not be allowed to penetrate into Scotland through the ignorance or carelessness of Scottish shellfish farmers. Any abnormalities or unusual mortalities should be reported to the Marine Laboratory, Aberdeen.

Exports of shellfish are also subject to certain controls depending on the destination. Some other countries require certification that the shellfish are free from diseases of shellfish and also from bacterial pollution which may be of danger to human health. Many areas in Scotland are normally free from bacterial pollution, but this fact is often not appreciated in other countries, and purification may be demanded. This consists of holding the shellfish in clean sterile sea water for 48 hours. The sterility of the water may be attained by using ultra violet light or small amounts of chlorine. It is most important to obtain advice on all these matters before the movements take place.

At times blooms of algae containing poisonous species occur in the plankton. The toxins from these species may be concentrated by filter-feeding shellfish such as mussels, oysters, scallops and queens to the extent that they become dangerous for human consumption. So far the levels in Scottish waters have rarely approached the level considered dangerous, but constant watch is kept during the summer months each year and if toxin is present the harvesting of molluscs in a particular area may be prohibited.

The setting up of a shellfish farm may have other implications and may meet considerable opposition from other interests if it detracts from local amenities or conflicts with existing operations. It is obviously advisable to operate in close consultation with all local interests, including the local landowner if access to the shore is required over his land. All permitted structures should be marked clearly to avoid danger to shipping and all these structures must be removed at the end of operations.

Shellfish accumulate heavy metals and it has been found recently that antifoulants containing organic tin compounds may cause abnormal growth in oysters, the shells of *Crassostrea gigas* becoming chambered (Plate VII), as well as various other effects on marine life. The use of such materials on boats is now regulated and it is expected that further regulations will be brought into force in the future and will control their use on salmon cages and other structures. In any case antifoulants should be used with considerable caution by all farmers as they are by nature poisonous.

Plate VII. Shell of *Crassostrea gigas* sectioned to show chambering.

Organisation of the Industry

At the present state of development of the industry, co-operation between growers is of the utmost importance. It is to the benefit of everyone to share their knowledge and experience and also to co-operate in both the acquisition of materials and equipment and the bringing of the shellfish to the market. In this connection attention should be drawn to the Scottish Shellfish Growers Association (address on page 19) which has been set up to further the ends of all shellfish growers in Scotland. Organisations which may under certain circumstances offer financial help include the Highlands and Islands Development Board and the Scottish Development Agency.

Several bodies can supply information of use to the shellfish grower. These include the laboratories of the Fisheries Departments, such as our own Marine Laboratory and the laboratories of the Ministry of Agriculture, Fisheries and Food including Torry Research Station which deals with handling and processing, the Sea Fish Industry Authority at Ardtoe in Argyll and the Scottish Marine Biological Association at Dunstaffnage near Oban (for addresses see pages 19 and 20).

A list of suggested reading matter will be found on page 19 and articles appear from time to time in such publications as "Aquaculture", "Fish Farmer" and "Fish Farming International".

Reading List

Barrett, J.H. and Yonge, C.M. 1964. Collins pocket guide to the seashore. London, Collins, 272 pp.

Drinkwater, J. and Howell, T.R.W. 1985. Experiments on the cultivation of oysters in Scotland. *Scottish Fisheries Research Report* No. 35. 20 pp.

Iversen, E.S. 1968. Farming the edge of the sea. London, Fishing News Books Ltd, 301 pp.

Korringa, P. 1976. Developments in Aquaculture and Fisheries Science. Vols 1 to 3. Amsterdam, Elsevier Scientific Publishing Co.

Mason, J. Production of mussels. *Nash, C.E. and Gall, G.A.E. eds. World Animal Science*. Amsterdam, Elsevier Scientific Publishing Co. (In press).

Mason, J. and Drinkwater, J. 1981. Experiments on suspended cultivation of mussels in Scotland. *Scottish Fisheries Information Pamphlet* No. 4. 15 pp.

Paul, J.D. 1987. An Introductory Guide to Cultivation of the Queen Scallop (*Chlamys opercularis*). Sea Fish Industry Authority Technical Report No. 297. 18 pp.

Walne, P.R. 1979. Culture of bivalve molluscs. Farnham, Surrey, Fishing News Books Ltd. 189 pp.

Yonge, C.M. 1960. Oysters. London, Collins. 209 pp.

Address List

Crown Estate Commissioners
10 Charlotte Square
Edinburgh EH2 4DR

Department of Agriculture and Fisheries for Scotland
Chesser House
500 Gorgie Road
Edinburgh EH11 3AW

Department of Agriculture and Fisheries for Scotland
Marine Laboratory
PO Box 101
Victoria Road
Aberdeen AB9 8DB

Department of Transport
Marine Division
Sunley House
90–93 High Holburn
London WC1V 6LP

Highlands and Islands Development Board
Bridge House
27 Bank Street
Inverness IV1 1QR

Ministry of Agriculture, Fisheries and Food
Torry Research Station
135 Abbey Road
Aberdeen AB9 8DG

Scottish Development Agency
120 Bothwell Street
Glasgow G2 7JP

Scottish Marine Biological Association
Dunstaffnage Marine Research Laboratory
PO Box 3
Oban
Argyll PA34 4AD

Scottish Shellfish Growers' Association
(Secretary) Janet Church
Tigh na Speir
Connel
Argyll PA37 1PH

Sea Fish Industry Authority
Marine Farming Unit
Ardtoe
Acharacle
Argyll PH36 4LD

Shellfish Association of Great Britain
Fishmongers' Hall
London Bridge
London EC4R 9EL

Stirling University Institute of Aquaculture
University of Stirling
Stirling FK9 4LA

Ed Rep 1m 7/88 (014331) (CRC suppli

PREVIOUS SCOTTISH FISHERIES INFORMATION PAMPHLETS

1977 No. 1 An Introduction to Commercial Fishing Gear and Methods Used in Scotland.
By E.S. Strange, 34pp.

1978 No. 2 A Guide to the Preparation of Net Drawings.
By E.S. Strange, 18pp.

1981 No. 3 A Method for Testing the Effectiveness of Different Fishing Baits in the Sea.
By A.D.F. Johnstone and A.D. Hawkins, 7pp.

No. 4 Experiments on Suspended Cultivation of Mussels in Scotland
By James Mason and J. Drinkwater, 15pp.

No. 5 The Calculation of the Twine Area of a Trawl Net.
By R.S.T. Ferro, 6pp.

No. 6 Choosing the Size of Suberkub Trawl Board to Suit a Pelagic-Type Four-Panel Trawl.
By R.S.T. Ferro, 5pp.

1982 No. 1 (Second Edition, Revised). An Introduction to Commercial Fishing Gear and Methods used in Scotland.
By E.S. Strange, 35pp.

No. 7 The Norway Lobster.
By F.G. Howard, 15pp.

1983 No. 8 The Marine Laboratory Four-Panel Trawl.
By R.D. Galbraith, 21pp.

1984 No. 9 Some Aids to the Design of Suberkub Otterboards.
By R.S.T. Ferro and B.J. Ritchie, 11pp.

No. 10 Principles and Practice of Stocking Streams with Salmon Eggs and Fry.
By H.J. Egglishaw, W.R. Gardiner, P.E. Shackley and G. Struthers, 22pp.

No. 11 Mesh Shrinkage in Fishing Nets.
By E.S. Strange, 14pp.

1986 No. 12 Design and Construction of Square Mesh Cod-ends.
By J.H.B. Robertson, 10pp.

Available from:–

The Librarian
Department of Agriculture and Fisheries for Scotland
Marine Laboratory
PO Box 101
Victoria Road
Torry
Aberdeen
AB9 8DB